

Amendments to the Claims

- 5 This listing of the Claims will replace all prior versions and listings of the claims in this patent application.

Listing of the Claims

- 10 Claims 1-91 (canceled)

92. (currently amended) A bonding structure on a chip comprising a pad exposed by an opening in a passivation layer, semiconductor device comprising:

- 15 a ~~pad having a region exposed by an opening in a passivation layer;~~
 a metal pillar over all region of said pad exposed by said opening in said passivation layer; all of said region; and
 a tin-containing cap over said metal pillar, wherein said tin-containing cap has a greatest transverse dimension less than a transverse dimension of said metal pillar.

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93. (currently amended) The bonding structure semiconductor device of claim 92, wherein said metal pillar comprises copper.

- 25 94. (currently amended - withdrawn) The bonding structure semiconductor device of claim 92, wherein said metal pillar comprises a tin-lead alloy.

95. (currently amended - withdrawn) The bonding structure semiconductor device of claim 92, wherein said metal pillar comprises gold.

- 30 96. (currently amended) The bonding structure semiconductor device of claim 92, wherein said metal pillar comprises a tin-silver-copper alloy.

97. (currently amended) The bonding structure ~~semiconductor device~~ of claim 92,
wherein said metal pillar cap comprises an electroplated metal.

5 98. (currently amended - withdrawn) The bonding structure ~~semiconductor device~~ of
claim 92, wherein said tin-containing cap further comprises lead.

99. (currently amended) The bonding structure ~~semiconductor device~~ of claim 92,
wherein said tin-containing cap further comprises bismuth.

10 100. (currently amended) The bonding structure ~~semiconductor device~~ of claim 92,
wherein said tin-containing cap comprises an electroplated metal.

101. (currently amended) The bonding structure ~~semiconductor device~~ of claim 92
further comprising a conductive layer between said metal pillar and said
15 tin-containing cap, said metal pillar having a height greater than that of said
conductive layer.

102. (currently amended) The bonding structure ~~semiconductor device~~ of claim 101,
wherein said conductive layer covers part of a top surface of said metal pillar.

20 103. (currently amended) The bonding structure ~~semiconductor device~~ of claim 101,
wherein said conductive layer covers all of a top surface of said metal pillar.

104. (currently amended) The bonding structure ~~semiconductor device~~ of claim 92,
25 wherein said tin-containing cap has a melting point lower than that of said metal pillar.

105. (currently amended) The bonding structure ~~semiconductor device~~ of claim 92
further comprising a metal layer between said metal pillar and said pad, ~~—and between~~
said-said metal pillar having a height greater than that of said metal layer.

30 106. (currently amended) The bonding structure ~~semiconductor device~~ of claim 105,
wherein said metal layer comprises titanium.

107. (currently amended) The bonding structure semiconductor device of claim 105,
wherein said metal layer comprises tungsten.
- 5 108. (currently amended) The bonding structure semiconductor device of claim 105,
wherein said metal layer comprises chromium.
109. (currently amended) The bonding structure semiconductor device of claim 105,
wherein said metal layer comprises copper.
- 10 110. (currently amended) The bonding structure semiconductor device of claim 105,
wherein said metal layer comprises nickel.
111. (currently amended) The bonding structure semiconductor device of claim 105,
15 wherein said metal layer comprises cobalt.
112. (currently amended) The bonding structure semiconductor device of claim 105,
wherein said metal layer comprises silver.
- 20 113. (currently amended) The bonding structure semiconductor device of claim 105,
wherein said metal layer comprises gold.
114. (currently amended) The bonding structure semiconductor device of claim 105,
wherein said metal layer comprises tin.
- 25 115. (currently amended) The bonding structure semiconductor device of claim 105,
wherein said metal layer comprises vanadium.
116. (currently amended) The bonding structure semiconductor device of claim 105,
30 wherein said metal layer comprises palladium.

117. (currently amended) The bonding structure ~~semiconductor device~~ of claim 105,
wherein said metal layer comprises a sputtered metal.
118. (currently amended) The bonding structure ~~semiconductor device~~ of claim 92,
5 wherein said tin-containing cap is on said metal pillar.
119. (currently amended) The bonding structure ~~semiconductor device~~ of claim 92,
wherein said metal pillar has a height greater than that of said tin-containing cap.
- 10 120. (currently amended) A bonding structure on a chip comprising a pad exposed by
an opening in a passivation layer, ~~semiconductor device~~ comprising:
a pad exposed by an opening in an insulating layer;
a copper pillar over said pad; and
a tin-containing cap over said copper pillar, wherein said tin-containing cap
15 has a greatest transverse dimension less than that of said copper pillar.
121. (currently amended) The bonding structure ~~semiconductor device~~ of claim 120,
wherein said tin-containing cap is on said copper pillar.
- 20 122. (currently amended) The bonding structure ~~semiconductor device~~ of claim 121
further comprising a metal layer between said copper pillar and said pad, said copper
pillar having a thickness greater than that of said metal layer.
123. (currently amended) The bonding structure ~~semiconductor device~~ of claim 122,
25 wherein said metal layer comprises titanium.
124. (currently amended - withdrawn) The bonding structure ~~semiconductor device~~ of
claim 120, wherein said tin-containing cap further comprises lead.
- 30 125. (currently amended) The bonding structure ~~semiconductor device~~ of claim 122,
wherein said metal layer comprises chromium.

126. (currently amended) The bonding structure semiconductor device of claim 120 further comprising a conductive layer between said copper pillar and said tin-containing cap, said copper pillar having a height greater than that of said conductive layer.

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127. (currently amended) The bonding structure semiconductor device of claim 126, wherein said conductive layer covers part of a top surface of said copper pillar.

128. (currently amended) The bonding structure semiconductor device of claim 126,
10 wherein said conductive layer covers all of a top surface of said copper pillar.

129. (currently amended) The bonding structure semiconductor device of claim 120, wherein said tin-containing cap has a melting point lower than that of said metal pillar.

15 Claims 130-150 (canceled)

151. (currently amended) A bonding structure on a chip comprising a pad exposed by an opening in a passivation layer, semiconductor device comprising:

20 a pad exposed by an opening in an insulating layer;
a metal pillar over said pad, wherein said metal pillar comprises a tin-silver-copper alloy; and
a tin-containing cap over said metal pillar.

152. (currently amended) The bonding structure semiconductor device of claim 151,
25 wherein said tin-containing cap is on said metal pillar.

153. (currently amended) The bonding structure semiconductor device of claim 152 further comprising a metal layer between said metal pillar and said pad, said metal pillar having a thickness greater than that of said metal layer.

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154. (currently amended) The bonding structure semiconductor device of claim 153, wherein said metal layer comprises titanium.

155. (currently amended - withdrawn) The bonding structure ~~semiconductor device~~ of claim 151, wherein said tin-containing cap further comprises lead.

5 156. (currently amended) The bonding structure ~~semiconductor device~~ of claim 153, wherein said metal layer comprises chromium.

157. (currently amended) The bonding structure ~~semiconductor device~~ of claim 153, wherein said metal layer comprises copper.

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158. (currently amended) The bonding structure ~~semiconductor device~~ of claim 151, wherein said tin-containing cap further comprises bismuth.

159. (currently amended) The bonding structure ~~semiconductor device~~ of claim 151
15 further comprising a conductive layer between said metal pillar and said tin-containing cap, said metal pillar having a height greater than that of said conductive layer.

160. (currently amended) The bonding structure ~~semiconductor device~~ of claim 159,
20 wherein said conductive layer covers part of a top surface of said metal pillar.

161. (currently amended) The bonding structure ~~semiconductor device~~ of claim 159, wherein said conductive layer covers all of a top surface of said metal pillar.

25 162. (currently amended) The bonding structure ~~semiconductor device~~ of claim 151, wherein said tin-containing cap has a melting point lower than that of said metal pillar.

163. (currently amended) The bonding structure ~~semiconductor device~~ of claim 120, wherein said copper pillar is electroplated.

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164. (currently amended) The bonding structure ~~semiconductor device~~ of claim 151, wherein said metal pillar comprises an electroplated metal.